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Wage response to global production links: Evidence for workers from 28 European countries (2005-2014)

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GDAŃSK UNIVERSITY OF TECHNOLOGY
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WAGE RESPONSE TO GLOBAL PRODUCTION LINKS – EVIDENCE FOR WORKERS FROM 28 EUROPEAN COUNTRIES (2005–2014)

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WAGE RESPONSE TO GLOBAL PRODUCTION LINKS – EVIDENCE FOR WORKERS FROM 28 EUROPEAN COUNTRIES (2005–2014)

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Abstract

By using very rich individual-level data on workers from 28 European countries, we provide the first so extensive cross-country assessment of wage response to global production links within global value chains (GVCs) in the period 2005–2014. Unlike the other studies, we (i) address the importance of backward links in globally integrated production structures (capturing imports of goods and services required *in any* stage of the production of the final product); (ii) measure the occupational task profile of workers with new country-specific indices of routinisation; (iii) compare the impact of global production links on wages between workers from Western, Central–Eastern, and Southern Europe employed in manufacturing and non-manufacturing sectors; and (iv) account for direct and indirect dependence on GVC imports from developing and high-income countries. We consider the potential endogeneity problems. Our results suggest that global import intensity of production exhibits negative pressure on wages in Europe. This effect mainly concerns workers from Western Europe employed in manufacturing and is driven by production links with non-high-income countries. Our counterfactual estimates suggest that the effect for all of Europe is small, but the pressure of GVC imports on wages in Western Europe is not economically negligible, in particular when inputs are from less developed countries including China.

JEL: F14, F16, J31

Keywords: wages, global value chains, global import intensity of production, tasks, EU

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1. Introduction

This paper addresses the research gap concerning a general absence of multidimensional cross-country evidence on factors determining wages in labour markets characterised by strong global value chain (GVC) links and task-related specificity of jobs. Using very rich individual-level data on workers from 28 European countries, we provide the first extensive assessment of wage response to global production links within GVCs in the period 2005-2014. The role played by cross-border production links, measured by using a novel measure of global import intensity of production (GII), is assessed in comparison with micro-level determinants of earnings (personal characteristics of workers, e.g. the task content of their jobs), and sectoral and country specificity.

Despite the impressive development in the literature on GVCs and value-added trade (among others: Antràs and Chor, 2013; Costinot et al., 2013; Johnson & Noguera, 2012; Johnson & Noguera, 2017; Koopman et al., 2014; Los, Timmer & Vries, 2015; Los et al., 2015; Timmer et al., 2015; Timmer et al., 2016; Baldwin and Lopez-Gonzalez, 2015), the studies on GVC, except for a few exceptions (Parteka and Wolszczak-Derlacz, 2016; Shen and Silva, 2018) have ignored its effects on labour markets.¹ Some of the papers (e.g. Amador and Cabral, 2015) have referred to GVCs but, in reality, describe labour market effects of offshoring; additionally, the two concepts—despite being closely linked—do not describe exactly the same phenomenon and should be measured in a different manner (Feenstra, 2017).

To the best of our knowledge, the GVC–wages nexus on the entire European labour market has not yet been analysed from the microeconomic task-based perspective². We are surprised that despite the recent slowdown of fragmentation within GVC (Timmer et al., 2016 document that it stagnated after 2011) and the dependence on foreign inputs, (as measured by GII, see Section 3.1 for details), this critical phenomenon remained unexplored. Between 2000 and 2014, the import intensity of European production (as percentage of European output) increased from 15.9% to 20.2%³. A bit less than one half of the increase can be attributed to the inputs used in the last stage of production (which roughly corresponds to conventionally measured offshoring). The remaining imported intermediates were required in the previous tiers of production and can be traced back in the GVC framework. The United States (U.S.) is less dependent on imported intermediates but, an increase of GII also occurred here (from 7.9% in

¹ Some firm-level research has investigated the impact of GVCs on firm-level productivity and/or efficiency, e.g. based on data for firms from New EU Member States (Hagemeyer, 2015), Canada (Baldwin and Yan, 2014), Italy (Brancati et al., 2017), or Thailand (Saliola and Zanfei, 2009).

² Many studies have investigated the impact of fragmentation (offshoring) on wages in Europe performed at the industry level (among others: Polgár and Wörz, 2010; Parteka and Wolszczak-Derlacz, 2015). However, they missed the important microeconomic level of wage-setting mechanisms and do not account for the importance of tasks specific to occupations.

³ Based on the GII index computed with the WIOD data (release 2016). See Section 3.1 (Table 1) for details.

2000 to 8.8 % in 2014). In the world, the ratio of GVC imports (e.g. imports by the country where the last stage of production occurred, and by all other countries involved in earlier stages of production) to the output of the final products was equal to approximately 16% in 2014 (12% in 2000). Importantly, only one third of it is attributable to the last stage of production; thus, the proper measurement of the dependence on foreign inputs required at the backward stages of production is necessary. So far, this aspect has been ignored in the literature on the labour market effects of fragmentation.

[Table 1 about here]

In general, the investigations on the European labour market effects of fragmentation that have considered the task content of jobs have another severe limitation: workers from only a few Western European countries were investigated. Consequently, although the task-based micro-level evidence on the consequences of production fragmentation for U.S. workers has been well documented (Acemoglu and Autor, 2011; Autor et al., 2014; Ebenstein et al., 2014), the data is more incomplete for Europe. An overwhelming portion of the research has investigated countries in the western part of the European Union: Germany (Baumgarten, 2015; Baumgarten et al., 2013; Becker et al., 2013; Becker and Muendler, 2015), Denmark (Hummels et al., 2014), the United Kingdom (Geishecker and Görg, 2011), or these three countries together (Geishecker et al., 2010). Moreover, no such evidence has been presented for other, less developed European economies (i.e. from Southern or Central and Eastern Europe, CEECS). So far, regarding trade or offshoring-labour markets, the literature on the CEECS markets have been analysed from the perspective of a potential threat to the Western European workers (Abraham and Konings, 1999; Geishecker, 2006; Dauth et al., 2014) or the effects observed within the CEECS (Egger and Egger, 2002).⁴ Furthermore, often only the impact on workers employed in the manufacturing sector has been analysed (as in Geishecker et al., 2010; Baumgarten et al., 2013, Hummels et al., 2014; Geishecker and Görg, 2011)⁵; thus, the samples covered by the literature has ignored a substantial portion of the European labour force employed in services or other non-manufacturing sectors, and these employees are likely to be affected by cross-country production links as well. The dependence on foreign production is sector specific and non-negligible in non-manufacturing activities⁶; thus, we do not limit our study to manufacturing.

⁴ The task-based literature has only shown that CEECs countries, similar to other well-developed economies, experienced a shift in employment, in particular, an increase in non-routine cognitive tasks and a decrease in the manual task content of jobs (Hardy, 2015; Hardy et al., 2016).

⁵ Baumgarten (2015) analysed the impact of material and business offshoring on the occupational instability of German workers. Becker et al. (2013) considered the sample of workers from German manufacturing and services sectors.

⁶ Timmer et al. (2016, p.25-26) revealed noticeable variation in the intensity of foreign inputs used in goods production and services production: many services are, of course, locally produced (e.g. public services, education,

Given this fragmentary research, we aim to assess if wages of broadly understood European workers are really impacted by the dependence on foreign inputs within GVC, given all the other dimensions of the wage determination process.⁷ Our main research question is thus the following: Are wages in Europe affected by the globally measured dependence on foreign inputs? To be more specific, can we assert that the degree of involvement in the integrated system of production is a significant (also in terms of magnitude) determinant of European wages, once the differences across individuals, job tasks, sectors, and countries are considered? If yes, workers from which European countries and performing what type of job are affected the most? What about the differences between manufacturing and the rest of the economy? Does the origin of imported inputs play a role?

To answer these questions, we construct a very rich dataset containing individual-level information on wages, occupational task profiles, and personal and job characteristics on 1.3 million workers, from 28 European countries, employed in the economy and observed in the period 2005–2014. We use harmonised data from the EU-SILC⁸ (European Union Statistics on Income and Living Conditions) and adopt proper weighting schemes; thus, we argue that our results are representative for the European labour market. We match our microdata with the input–output measures of sectoral dependence on foreign inputs, other sector characteristics, and information on countries’ labour market institutions and wage bargaining schemes. As a result, by relying on such multidimensional data, we explore several dimensions of wage determination in Europe, with the involvement into global production structures as *one* of its potential determinants.

In addition to the wide country coverage, our analysis differs from the literature in several other aspects. First, so far the effects of fragmentation were analysed as if the intensity of the use of foreign inputs was independent from the previous stages of production (i.e. performed domestically or abroad). Conventional measures of fragmentation are based on the ratio of imported intermediates to the production value of an industry under consideration (Feenstra and Hanson, 1999), that is, they use the information on the last stage of production only and ignore

recreation) but, for instance, the production of construction works is as much dependent on foreign inputs as some manufacturing industries. In a recent paper Johnson and Noguera (2017) documented that, over time (1970–2009), the ratio of value added to gross exports decreased within manufacturing (by 20 p.p.) but increased in agriculture and services.

⁷ We limit our focus to the effects exhibited on wages and treat employment and labour demand effects of fragmentation as topics requiring a separate task-based investigation. See Ebenstein et al. (2014) for the joint micro-level analysis of production fragmentation effects on wages and employment shifts in the U.S.

⁸ More on how harmonisation procedures of original datasets contributed to the EU-SILC database (Statistics on Income and Living Conditions), along with the description of the EU-SILC database (country and variables coverage) and a complete documentation, can be found at: <http://ec.europa.eu/eurostat/web/microdata/european-union-statistics-on-income-and-living-conditions>.

the previous parts of the production chain. By contrast, we consider cross-country and cross-industry backward links along the whole sequence of production. We measure the importance of backward links in globally integrated value chains by employing the newest release of the WIOD data⁹ and methodological developments proposed by Timmer et al. (2016). Next, fragmentation is proxied by a novel index of global import intensity of production (*GII*). *GII* captures imports of goods and services required *in any stage* of the production of the final product and involves third-country trade. Our approach is thus closer to the framework of the sequential production framework and national interdependence driven by vertical specialisation and GVCs (Antràs and Chor, 2013; Kohler, 2004; Costinot et al., 2013), rather than to the ‘classic’ offshoring literature using information on imported inputs employed in the last tier of production chain in isolation from the previous stages. The two phenomena, offshoring and GVC, are linked (‘outsourcing involves a fragmentation of value added across national borders’ - Kohler, 2001: 50). However, their measurement differs and ‘second-generation statistics’ on fragmentation based on input–output data are a better reflection of the notion of multistage cross-border production links (Feenstra, 2017).

Second, we verify whether the impact of *GII* on wages in Europe depends on the source of imported inputs used along the production chain. Evidence in the literature has confirmed that the provenience of inputs is critical. Becker et al. (2013) demonstrated that the offshoring of German MNEs to low-income countries (except Central and Eastern Europe) has a stronger onshore employment response. Wolszczak-Derlacz and Parteka (2018) used industry-level wage information and decomposed the input–output offshoring measure by the source country and found a negative (but small) downward pressure of offshoring from low-wage countries¹⁰ on wages in a worldwide 40-country sample. Our approach is noticeably different from these (and other) offshoring studies. First, we consider *all* the backward tiers of production. Hence, in our setting, we account for the direct (at the last stage of production, e.g. conventional offshoring measurement) and indirect (along the whole value chain) effects of dependence on intermediates. Second, we compare the effects of the dependence of the value chain on foreign inputs measured globally, independently of the country of origin, with the dependence on inputs from only less developed countries.

Third, at all the stages of our analysis, we consider the occupational task profile of workers, which *varies across countries*. Given our cross-country approach, another important feature

⁹ World Input Output Database, November 2016 release (see Timmer et al., 2015 for details).

¹⁰ Importantly, their classification of low-wage countries is not based on aggregate data but is based on relative wage levels and varies across industries and time (available at https://static-content.springer.com/esm/art%3A10.1007%2Fs10663-016-9352-4/MediaObjects/10663_2016_9352_MOESM1_ESM.xlsx).

of our data is the use of *country-specific* routinisation indices (Hardy et al., 2018a). This approach reflects that, for instance, the assemblers in Germany and Romania should not have the same value a routinisation index with the same value because the tasks they perform differ due to technological and organisational differences between these countries. The previous task-based labour market studies have either focused on one country (for which the classification of tasks was available, such as the United States: Autor and Handel, 2013; Autor et al., 2014; Ebenstein et al., 2014 or Germany: Baumgarten, 2015; Becker et al., 2013) or assumed that the task profile of workers from the analysed countries is the same as that in the United States (based on O*NET data). This assumption was very simplifying. For instance, Goos et al. (2014), Arias et al. (2014), Lewandowski et al. (2017), and Hardy et al. (2018b) have applied O*NET to LFS data in the European Union and/or OECD countries, whereas the World Development Report (2016) utilises the typology of occupations by Autor (2014) and based on U.S. data to analyse changes in employment shares in developing countries.

The structure of our paper is as follows. Section 2 briefly describes the theoretical background of our study and key related contributions on production fragmentation and wages in Europe, which our paper expands on. Section 3 presents the data and methodological setting and focuses on the measure of global dependence on foreign inputs and on wages in Europe. The empirical strategy and results of the estimations calculated across various subsamples of the data are presented in Section 4. The last section concludes. Numerous robustness checks are included in the additional material and available in the appendix.

2. Related literature

2.1 Theoretical background

Theoretically, our paper is at the crossroads between the literature on the effects of offshoring on domestic workers and sequential production, which can be adopted to GVC analysis.

Considering the conceptualisation of offshoring through trade-in-tasks, the impact of the growing dependence on foreign inputs on wages can operate indirectly through three main channels: the influence on relative labour demand, productivity, and relative prices. Theoretical models (Grossman and Rossi-Hansberg 2008) have addressed the ambiguity of production fragmentation effects on domestic labour demand by studying these three contrasting forces. A negative relocation effect occurs if domestic workers are replaced by foreign workers (which leads to a domestic labour wage decrease, in particular, those workers whose tasks are easier to offshore), whereas a positive productivity effect (driving up wages) operates when offshoring

reduces firms' production costs, leading to an increase in the demand for domestic labour. If productivity gains due to production relocation are sufficiently large, they may actually result in wage gain that includes workers performing less demanding tasks.

Models of sequential, multistage production, and the theories of countries' interdependence driven by vertical specialisation (Costinot et al., 2012; Costinot et al., 2013; Antràs and Chor, 2013; Kohler, 2004;), have also provided ambiguous theoretical predictions regarding how the participation in the production chain affects factor prices (e.g. wages). However, the models have confirmed that in a world of globally integrated production, the outcomes (e.g. wages) observed at one stage (e.g. final) should not be analysed separate from what occurs at the previous stages of the production process. Kohler (2004) argued that the ambiguity of the response of wages to production fragmentation is magnified by the presence of cross-industry links in a multistage production setting. Costinot et al. (2013) developed a simple theory of trade with sequential production to show how global supply chains affect the interdependence of nations. They subsequently extended this framework (Costinot et al., 2012) to a multifactor version and studied the implications of global supply chains for wage inequality. In such a model, with sequential production, changes in wages reflect changes in the prices of the intermediate goods used by these workers. Hence, efficiency gains due to the use of cheaper foreign inputs used at previous stages of production can indirectly affect productivity at subsequent stages, affecting the wages of workers therein employed. Such a perspective motivates our empirical approach, where the previous tiers of production, performed offshore, can impact the domestic wages of workers employed domestically in the latter stages of GVC closer to the final demand.

2.2. Production fragmentation, GVC, and wages in Europe – empirical evidence

Generally speaking, the recent development of empirical literature on the fragmentation–wages nexus follows the influential theoretical models of trade-in-tasks (Grossman and Rossi-Hansberg, 2008; Grossman and Rossi-Hansberg, 2012; Baldwin and Robert-Nicoud, 2014). The empirical literature that had built upon these theories attempted to bring the analysis closer to the reality. The approach, based on the division of workers into skilled and unskilled categories, that was commonly used in the first wave of studies on labour market consequences of production fragmentation for different workers, is no longer sufficient. In particular, tasks clearly differ from skills, especially when wanting to assess the offshorability potential of particular occupations

(Blinder, 2006; Blinder and Krueger, 2013).¹¹ Consequently, to evaluate the consequences of globalisation for heterogeneous workers, the empirical international trade research has adopted the task setting, originally developed to analyse variation in skill requirements within occupations and the changing task composition of the labour markets due to technological progress (among others: Spitz-Oener, 2006; Autor et al., 2003; Acemoglu and Autor, 2011; Autor and Handel, 2013).

Much of the task-based evidence on the labour market implications of production fragmentation (offshoring) is available for the United States (recently: Ebenstein et al., 2014; Autor et al., 2014) and a large portion of this literature has focused on the so-called ‘China syndrome’ (among others: Autor et al., 2014; Shen and Silva, 2018). Given our focus on Europe and the microeconomic task-based approach, we present a few papers closely related to our research (i.e. we exclude the literature using industry-level data, such as Polgár and Wörz, 2010; Parteka and Wolszczak-Derlacz, 2015; Wolszczak-Derlacz and Parteka, 2018). The more detailed evidence, which considers the heterogeneity of workers in terms of individual characteristics is strongly dependent on microdata availability, which is why in Europe, the cases of very few countries (mainly Germany) dominated the debate.

Of the European countries, Germany is by far the most intensively analysed case. Becker and Muendler (2015) documented significant trade-task changes in the German economy over three decades (1976–2006): imports of intermediates grew, and the German workforce increasingly specialised in non-offshorable activities. Baumgarten et al. (2013) demonstrated a negative wage impact of offshoring dependent on the task profile of workers' occupations (the higher non-routine content of jobs effectively protects workers from the negative wage consequences of production relocation). Becker et al. (2013) used plant level data for German MNEs to examine the relationship between offshoring and the composition of skills and tasks in Germany. Their results suggested positive relationships between offshore employment and the wage–bill shares of non-routine and interactive tasks. However, they found that the economic effects of offshoring on the composition of the labour force are modest and concluded that much of the variation in the wage–bill shares is explained by factors other than offshoring.

The evidence available for other countries confirms that offshoring tends to exhibit uneven effects on workers, which is dependent on the skill/task type. Hummels et al. (2014) used matched worker–firm data from Denmark and demonstrated that offshoring increases the wages of high-skilled workers and decreases the wages of low-skilled workers. However, given that skills

¹¹ Baumgarten et al. (2013) showed substantial heterogeneity between skills and tasks when assessing the cross-industry effects of offshoring on wages in German manufacturing.

do not overlap perfectly with tasks, the wage effects vary according to tasks (i.e. workers performing routine tasks suffer the most). Geishecker and Görg (2013) merged industry-level data on offshoring for the United Kingdom with individual-level data on wages (their setting is thus similar to ours) and showed that the offshoring of services negatively affects the wage of low- and medium-skilled workers and leads to a wider skilled–unskilled wage gap. Finally, Geishecker et al. (2010) combined the data for Germany, the United Kingdom, and Denmark to assess if the differences in labour market institutions led to differences in the impact of outsourcing on wages across these three countries. Surprisingly, they concluded that the estimated effects are, actually, quite similar across countries and fairly small.

Few studies have explicitly addressed the GVC–wages nexus and based on industry-level data on GVC merged with individual-level worker data on wages. Shen and Silva (2018) studied the relationship between value-added exports from China and wages in the United States and demonstrated that the effects depend on the position of the Chinese industry in the GVC (in terms of the degree of downstreamness). The research by Parteka and Wolszczak-Derlacz (2016), who constructed a cross-sectional dataset on nine European countries and the United States, is the most similar to our paper in terms of the data and methodological setting. Their results suggested that growing cross-border industrial interdependence (measured in terms of industrial foreign value-added share) negatively affects the wages of some workers, namely, those who perform more routine tasks and have less education. The effects that they identified empirically are, however, quite modest. Their study, however, did not cover the whole European labour market, used a crude classification of workers according to the task content of occupations, and failed to explore the role of backward production ties in multistage GVCs. We address these limits in the subsequent analysis.

3. Empirical setting

This study considers workers from 28 European countries: Western Europe is W (AT, BE, CH, DE, DK, FI, FR, IE, IT, NL, NO, SE, UK); Southern Europe is S (CY, ES, EL, P); and Central and Eastern Europe is CEECS (BG, CZ, EE, HU, LT, LU, LV, PL, RO, SI, SK). We match micro-level information (from the EU-SILC) with sector-level statistics on countries' dependence on foreign inputs based on WIOD (released November 2016).

3.1 The measurement of GII

To measure countries' and industries' global dependence on imported inputs, we draw on the

new accounting framework in Timmer et al. (2016), used to explain the global trade slowdown.¹² By following them, we employ the newest available release of industry-level data from the WIOD (November 2016) to compute the ‘global import intensity of production’ (*GII*) index. *GII* is a backward measure that considers “*the imports by the country in which the last stage of production takes place, as well as imports by other countries that are involved in earlier stages of production. Moreover, it includes imports of intermediate goods as well as intermediate services (such as supporting business services)*” (Timmer et al., 2016, p.4). *GII* thus noticeably differs from the offshoring intensity measured (in the spirit of Feenstra and Hanson, 1999) at one stage of production as only a ratio of imported inputs to the industrial output value. *GII* measures all the imports of intermediates by all countries in the value chain induced by a dollar of output of a final product. Consequently, its interpretation in terms of total contribution of foreign inputs into the domestic production is also straightforward, by contrast with the measures based on export decomposition [vertical specialisation (VS) - domestic value added in exports: Hummels et al., 2001; Koopman et al., 2014 or the VAX ratio - value-added exports: Johnson and Noguera, 2012].¹³

We adopt a sequential approach to measure the dependence on foreign inputs, namely, we use the information on imported inputs employed in the last stage of production and on imported inputs employed in all the previous production stages (backward movement along the GVC). Formally, *GII* is computed as follows (Timmer et al., 2016, p. 10-12)¹⁴. Let $a(t,j)(u,k)$ be the value of inputs from industry t in country j required by industry u in country k to produce one dollar of its gross output. Good z is finalised in (s,i) . All imports required in each stage (tier) of production of good z are defined as follows:

$$h_z^{tier0} = \sum_u \sum_{k \neq i} a(u,k)(s,i)$$

$$h_z^{tier1} = \sum_t \sum_{j \neq k} \sum_u \sum_k [a(t,j)(u,k)] [a(u,k)(s,i)]$$

$h_z^{tier2} = \dots$ and so forth; thus, the *GII* of z is equal to

$$GII = h_z = h_z^{tier0} + h_z^{tier1} + h_z^{tier2} + \dots = \sum_t \sum_{j \neq k} \widehat{a}_z(t,j)(u,k) \quad (1)$$

where $\widehat{a}_z(t,j)(u,k)$ is the delivery of inputs from (t,j) to (u,k) induced by the production of good

¹² In particular, they argued that before the economic crisis, the import intensity was increasing due to high demand for durables and increasing international production fragmentation; after 2011, the fragmentation growth halted, and the demand shifted to services.

¹³ The recent empirical evidence on long-run trends (four decades: 1970–2009) in value-added exports is provided by Johnson and Noguera, (2017), whereas Baldwin and Lopez-Gonzalez (2015) presented an overview of supply-chain trade developments since 1995 (from the perspective of: importing to produce; importing to export, and value-added trade).

¹⁴ The notation and description of *GII* in this section comes from the presentation of M. Timmer at HKUST Conference on International Economics, Hong Kong, June 1–2, 2017.

\tilde{z}

The production of intermediate inputs provided by the first-tier suppliers involves intermediates from second-tier suppliers and so forth, summing up to all the tiers of production given by *GII*. Empirically (by using input–output tables and following Leontieff), gross output related to the production of final good \tilde{z} is derived as: $\mathbf{Y}_z = (\mathbf{I} - \mathbf{A})^{-1} [\mathbf{z}]$, where \mathbf{A} is the matrix of intermediate input coefficients (foreign and domestic), and \mathbf{I} is the identity matrix. Intermediate inputs linked to the production of good z are then given by $\widehat{\mathbf{A}}_z = \mathbf{A} \text{diag}[\mathbf{Y}_z]$. All intermediate imports related to \tilde{z} are given by $h_z = \mathbf{u}'(\mathbf{T}^\circ \widehat{\mathbf{A}}_z) \mathbf{u}$, where \mathbf{T} is an indicator matrix (with zero's for domestic flows and \mathbf{u} being a summation vector). *GII* takes the values between 0 and 1¹⁵, where zero means that the finalising country does not have to import intermediates in *any* stage of production of product z , and the value of 1 indicates a complete dependence on foreign inputs along the value chain.

Figure 1 shows the average values of *GII* in our sample of 28 European countries in 2014 (i.e. the last year of input–output data in the WIOD, and the last year of our analysis; values are weighted by the industry value added). *GII* (expressed as an index 0–1, where the value of 1 corresponds to a total, 100% dependence of the final production is on imported inputs, and calculations are performed along all the backward stages of production) range between 13% of final output in Greece to 55% in Luxembourg. European countries are generally more dependent on foreign inputs than bigger economies like United States or China, where *GII* equals, respectively, 0.08 and 0.13 (8 and 13%). In almost all of the countries, less than half of *GII* is driven by imports by the country in which the last stage of production occurred (in black), and the other half depends on inputs imported in earlier stages of production which involve third-country trade. This result means that conventionally measured offshoring (which accounts for imported intermediates employed in the last stage of production) can severely underestimate the importance of global sourcing and its indirect effects on domestic labour markets.

[Figure 1 about here]

Some of the industries are much more dependent on foreign inputs than others, for example, the global import intensity of services production tends to be much lower than for goods (Timmer et al., 2016: 4). Table 2 reports values of *GII* for the whole economy (all industries) and by sectors. To present a comparison, we show the data typical for Europe 28 and the three subgroups of European countries, split into Western (W), Southern (S), and Central and Eastern countries (CEECs) in 2014. *GII* is clearly the highest in the manufacturing industries (e.g. in

¹⁵ Theoretically, *GII* can be greater than 1 when imports are measured on a gross basis and double counting of value added contributions occurs (see Timmer et al., 2016: 11; Koopman et al., 2014), but we exclude such (few) observations from the sample.

Western Europe, GVC imports account for 42% of the final manufacturing production), but the ratio of imported intermediates to the final output is also considerable in services, construction, or agriculture. In Europe, value chains finalised in the CEECs are more dependent on imported inputs than in the case of the Western or Southern European countries. This result is a sign of the significant involvement of CEECs in GVCs.

[Table 2 about here]

Our further input is to compute the variants of GII , which measure the reliance of the value chain linked to the production of ε on the intermediates from the different subgroups of countries. At every backward stage of production, we use the information on the source (country) of intermediates, and sum them over those coming from high-income countries only (GII^{HIC}) and selected developing countries only (GII^{DEV}), encompassing China and India¹⁶; in particular, by using the latter measure, we assess the direct and *indirect* effects of production dependence on the countries in the south characterised by lower labour costs. According to the values reported in Table 3 (Panel B), GVC imports from these developing countries account for a very small share of final output, that is, only 3%, whereas in Europe, this percentage is even lower (2%). In manufacturing it is 6%, which still is not much. Additionally, the values of GII^{HIC} are considerably higher than GII^{DEV} : in Europe, on average, the value of imported intermediates employed along the value chain and coming from other well-developed economies accounts for 14% of the final output (31% in manufacturing). Thus, given the magnitude of the dependence on developing countries' inputs, the negative consequences of imports from countries like China are likely to be overvalued.

[Table 3 about here]

Cross-country variability in GII and the changes between 2005 and 2014 (the years of our analysis) are shown in Table 4. Additionally, to show the importance of the proper backward measurement of foreign inputs, we report the values of GII_tier1 , encompassing imports from first-tier suppliers only. The interpretation of the values is as follows: for instance, one dollar of goods and services finalised in Germany (DE) generated approximately 16 dollar cent of imports worldwide in 2005 increasing to 20 dollar cent in 2014. Additionally, imported intermediates used in the last stage of production only, accounted for 7 cents in 2005 and 9 cents in 2014 per each one dollar of final German production. In general, the ratio of GVC imports to output increased

¹⁶ *HIC (high income countries)*=AUS, AUT, BEL, CAN, HRV, CYP, CZE, DNK, EST, FIN, FRA, DEU, GRC, HUN, IRL, ITA, JPN, KOR, LVA, LTU, LUX, MLT, NLD, NOR, POL, PRT, SVK, SVN, ESP, SWE, CHE, TWN, GBR, USA; *DEV (developing countries)*= BRA, BGR, CHN, IND, IDN, MEX, ROM, RUS, TUR; *RoW*=world – 43 countries present in WIOD2016 = world – *HIC-DEV*. The classification of countries is based on the World Bank's list of economies (July 2016).

in all of the European countries (except Spain, ES, and Sweden, SE). This result could be either due to the imports increase in any stage of production or new stages of production (with similar import requirements) added to GVC causing its lengthening.

[Table 4 about here]

3.2 Microdata and descriptive statistics on wages

The micro-level data for our empirical analysis is from the EU-SILC database, obtainable from Eurostat¹⁷. The EU-SILC provides comparable cross-sectional and longitudinal multidimensional microdata on income, poverty, social exclusion, and living conditions, and is thus suitable for cross-country comparisons¹⁸. This study uses a cross-sectional type of data provided by EU-SILC (optionally, longitudinal data is available, but some crucial variables required in our empirical analysis are absent, e.g. the sector of employment used to merge the microdata with sector-level data on GII). Data are gathered in two types of files, depending on the level of response: individual and household. We combine individual files (personal data and personal register) with household information (household data and household register) on the basis of the following matching variables: year, country, individual id, and household id. Our analysis is performed on the pooled waves of the EU-SILC data covering the years 2005–2014¹⁹ and 28 European countries²⁰.

The key variable of interest (our dependent variable), hourly wage, is computed on the basis of variables from the EU-SILC data files. By using the information on gross annual employee income²¹, the number of months worked during the income reference year and average number of hours worked per week, we calculate hourly earnings (gross hourly wages) with the assumption of the average number of 4.2 weeks worked per month. Alternatively (we use this variable for the

¹⁷ The access to EU-SILC and other microdata from Eurostat is granted to researchers on the bases of respecting rules of confidentiality. This study is based on data from Eurostat, EU-SILC, *EUSILC UDB 2015 – version 1 of August 2016* - access has been granted by the Eurostat under the grant agreement 64/2013-LFS-EU-SILCSES. The responsibility for all conclusions drawn from the data is entirely with the authors.

¹⁸ The documentation of EU-SILC can be found at: <http://ec.europa.eu/eurostat/web/microdata/european-union-statistics-on-income-and-living-conditions>. To transform the original csv files into the Stata format, we used the routines from Gesis (prepared by Heike Wirth, <http://www.gesis.org/en/missy/materials/EU-SILC/setups>).

¹⁹ Theoretically, the data for 2015 is also present; however, for the limited number of countries. There are some differences between the data collected under different waves. The documentation we rely on is provided (along with the data files) in EC (2016).

²⁰ Out of the 32 countries covered by the EU-SILC, two are not reported in the WIOD (Iceland and Serbia), for Malta and Croatia, the amount of missing information referring to hourly wages and specific aggregation of other variables do not allow us to include them in the final sample.

²¹ We consider gross employee cash or near cash income, which refers to the monetary compensation of employees in cash payable by an employer to an employee; among others, it includes wages and salaries paid in cash for time worked or work done, holiday payments, payments for overtime, additional payments (e.g. thirteenth month payment, payment based on one's productivity, commissions, tips and gratuities). Gross means that neither taxes nor social contributions have been deducted.

robustness checks²²), for countries providing information on the income reported for the actual period, we calculate gross hourly wages from the information on monthly gross earnings and number of hours worked per week (as in Schäfer and Gottschall, 2015).²³ Because the data for hourly wages calculated with the use of monthly earnings is available for a limited number of countries (e.g. in 2014 for 12 countries), in the main analysis, we use the former method of wage calculation. Wages are expressed in EUR, and based on the conversion rate provided in the EU-SILC. Additionally, we use the HICP from Eurostat to report wages in real terms (HICP 2015 = 100).

For the purpose of our analysis, we employ other micro-level variables from the EU-SILC, which are important for the determination of wages. The set of individual characteristics consist of sex, age, marital status, education (based on the highest ISCED level attained and reclassified into groups with high education; ISCED levels 6, 7, and 8 or less than high education; ISCED levels from 0 to 4).²⁴ Labour characteristics include the size of the company an employee works for (micro firm if less than 11 persons are employed, medium is 11–49 employees, and big is 50 or more employees), the type of contract (permanent vs temporal, e.g. a work contract of limited duration), managerial position (if the work includes supervisory responsibilities), the sector of employment (NACE Rev. 1.1 for 2004–2007 and NACE Rev. 2 for 2008 onwards), and occupation (following 2 digit ISCO-88 classification till 2011 and ISCO-08 afterwards)²⁵.

We restrict our sample to full-time workers in the working age population, aged 18–65, for whom we have the data to compute wage measure and the information regarding their occupation and sector of employment. Additionally, we exclude armed forces occupations. To eliminate outlier values in our sample, we correct the top and bottom distribution of wages. At the bottom, we trim the distribution at the 1/100 of the country-specific mean, and at the bottom, wages greater than ten times the national median are set to ten times the national median. The trimming is performed for each year and each country, separately²⁶. In Table 2A, in

²² The key results obtained with wages calculated on the bases of monthly earnings are reported in Table 5A in the appendix.

²³ The methods of wage calculation from the EU-SILC income data are described in Engel and Schaffner (2012). In our sample, the correlation between gross hourly wages calculated on the basis of annual income and monthly earnings is high and equals 0.86.

²⁴ Unfortunately, the data on experience (the number of years spent in paid work) is missing for: DK, EL (2005–2009), FI, HU, NO, SE, UK (2005–2009); thus, we do not include this variable in our wage regression. However, the correlation between age and experience is very high (0.9); thus, age should be a good proxy for work experience as well.

²⁵ Our concordance between sectors and occupations considers the changes in classifications over time. For the period of time when the old classification existed, we match data of individual workers from qw EU-SILC with other variables, e.g. sectoral variables based on that old classification; after the classification changed, we use the most recent schemes.

²⁶ Alternatively, we considered trimming the distribution at the bottom at the 1st percentile and at the top at the 99th percentile of country- and year-specific wages. This does not change the results effectively.

the appendix, we report summary statistics for all the micro-level variables. The average worker in our sample is 41 years old with 19 years of work experience who earns 14 euro per hour; 60% of workers are males and 32% have a tertiary education; 56% are married, almost half are employed in a big firm, 89% have permanent contract, 11% have a temporary job contract, and 28% hold managerial positions that include a formal responsibility to supervise a group of other employees, at least sometimes, and do some of the work ²⁷.

A critical feature of our data is we can quantify the routine content of jobs of particular workers. For this purpose, we use country-specific routine intensity indices (RIIs) that reflect the differences in routinisation between particular occupations, but also between countries (Hardy et al., 2018a)²⁸.

Given that our primary interest is the evolution of wages, Figure 2 presents boxplots of wages by task quartile and skill group. For this purpose, we compute country-specific quartiles of RTI indices to divide workers into four categories where the bottom category contains workers with the lowest degree of job routinisation (1st quartile of RTI), and the top category refers to workers with the highest degree of job routinisation (4th quartile of RTI). More important, because we use country-specific routinisation indices, the job routinisation of each worker is assessed regarding the national distribution of tasks. Skill groups (1–4, where 1 is the lowest and 4 the highest) are defined on the basis of ILO (2012) methodology mapping major ISCO groups to skill levels. We are not surprised that higher wages are paid to workers performing occupations that require high skills and are less routine. The box plots²⁹ also show noticeable dispersion of wages within each category.

[Figure 2 about here]

Cross-country differences in wages are observed. Table 5 shows average wages, by RTI quartile, in the three groups of European countries (Table 13A in the Appendix shows the analogous country-specific values). We are not surprised that the highest wages are reported for those performing low routine occupations, namely, the first quartile of RTI (e.g. in Western Europe the

²⁷ The comparison of these values with the data reported by Eurostat proves that our sample reflects the European labour market quite well. For instance, according to the official statistics, 34.2 % of the 25–54-year-olds in the EU-28 had completed tertiary education (source: Eurostat, edat_lfs_9903, 2017); the proportion of employees aged 15–74 in the EU-28 with a contract of limited duration (fixed-term employment) was 14.2 % (source: Eurostat, lfsa_esegt, 2016); lower employment rates are observed for women than men (gender employment gap equals to 11.5 p.p., source: Eurostat, lfsa_ergan, 2017).

²⁸ We would like to thank Piotr Lewandowski from IBS Warsaw for sharing their country-specific indices of routinisation (see Hardy et al., 2018a for methodological details on their computation). The set of indices is available for 42 countries that participated in PIAAC, STEP, and CULS surveys. For some of the countries, we attribute the values of the most similar country (i.e. economic development, location, and size). Our results remain robust when we employ alternative country-specific and standard (non-country specific) indices of routinisation (Table 5A in the appendix).

²⁹ The line inside each box corresponds to the median wage value. The box edges show the 25th and 75th percentile. The lines extending from the box indicate the variability outside the upper and lower quartiles

average wage in such occupations equals almost 24 euro per hour, and in CEECs 5 euro). Workers employed in the most routine-intensive jobs earn considerably less. This tendency is stable across countries.

[Table 5 about here]

Is this a sign that major GII is among significant determinants of wages, once all other factors influencing the wage determination process are considered? We address this question in Section 4.

4. Empirical model and estimation results

4.1 Results

Our empirical strategy is based on the estimation of individual wage regression augmented with the measure of the dependence of domestic production on foreign inputs, namely, GII, typical for a sector in which a given person is employed. A similar approach has been adopted (among others) by Baumgarten et al. (2013), Geishecker et al. (2010), and Ebenstein et al. (201,) who merged micro-level data on labour market outcomes with sectoral observation on offshoring intensity, or Parteka and Wolszczak-Derlacz (2016), who combined individual wage data with statistics on sectoral foreign value-added share.

First, we estimate the following model:

$$\ln wage_{ijoct} = \alpha + \beta X_{it} + \gamma Job_{it} + \delta RTI_{oc} + \theta GII_{jct} + \mu \ln Prod_{jct} + D_t + D_j + D_c + \varepsilon_{ijoct} \quad (2)$$

where i denotes a worker employed in sector j in occupation o in country c at time t . We regress the log of the gross hourly wage ($\ln wage$) on a set of personal characteristics X (sex, age, age², marital status, education), job characteristics Job (firm size, type of the contract, managerial position), and information on the routine content of occupation RII (routine intensity index). We augment the model with the information on global import intensity (GII where $GII = [0 - 1]$), so coefficient θ represents the elasticity of wages with respect to the globally measured dependence on foreign inputs. As sectors that are more productive are likely to pay higher wages, we also include productivity ($Prod$) measured as the ratio of real sectoral value added to the total number of hours worked by employees as an additional industry-level control. Additionally, we include time effects D_t (controlling for time specific economic fluctuations, e.g. the 2008/2009 crisis), industry dummies D_j (allowing for all the remaining industry-specific characteristics or wage regulations), and country dummies D_c (picking up all country-specific conditions, e.g. labour

market institutions and wage-setting mechanisms).³⁰

Eq. (2) is estimated by using weighted regression (with normalised weights based on the original personal weights provided by the EU-SILC and normalised by the number of observations per country to sum up to 10,000 within each country) and robust standard errors clustered at the country–industry level. Given the potential endogeneity between the use of foreign inputs (and thus offshoring activity) and wages, we adopt an instrumental variables estimation. *GII* is instrumented by foreign value added embodied in exports (*FVA*)³¹, which is correlated with production fragmentation but neutralises the potential effects of demand conditions in an importing country. We observe that instruments are correlated with *GII* and orthogonal to the changes of individual workers’ wages. The choice of the instruments is confirmed by under- and weak identification tests.

[Table 6 about here]

The first two columns of Table 6 present the estimation results of the basic specification (eq. 2) based on pooled OLS, and they differ regarding a set of explanatory variables (information on contract type and managerial position are not available for all workers). Columns 3 and 4 report the analogous IV estimations. On average, male, older, married workers with higher education earn more. Additionally, higher wages are characteristic of employees working in medium and big companies (in relation to small firms) that have a permanent contract and hold managerial positions that require supervisory responsibilities (columns 2 and 4). Hence, in all the specifications, the obtained coefficients concerning workers’ individual and job characteristics are in line with the microeconomic theory of wage determination (the Mincerian model); to save space, in the subsequent tables, we do not report them. We are not surprised that the degree of routinisation measured by *RTI* is a significant and negative determinant of wage level. The higher the routine content of a job, the lower the wage.

Regarding industry-level characteristics, employment in more productive sectors is associated with higher wages, and sectors with a more intensive process of international production fragmentation (higher *GII*) offer lower wages. Table 7 reports the negative relationships between hourly wage and job routines, and that between *GII* and wages are not sensitive to the set of other control variables included in the model as wage determinants. The magnitude of the wage effect of *GII* is higher when the endogeneity is considered; from now on, we concentrate on IV estimations. To conserve space, we report coefficients for *GII* and the

³⁰ In the robustness section, we add to the estimation more information about the characteristics of labour market institutions that vary across countries. The results are reported in Table 6A.

³¹ *FVA* share in gross exports is calculated on the bases of export decomposition performed on the WIOD’s data, by using the procedure from Wang et al. (2013).

routinisation level only, but all the models include personal and employment controls, industry characteristics (productivity), time, country, and industry dummies.

[Table 7 about here]

The basic specification was estimated on the full sample of countries, sectors, and GII independent of the source country of the imports. To understand the impetus of the effect of GII on wages, we re-run the estimations, taking into account GII computed on the basis of the information of inputs employed in the value chain and exclusively from high-income countries (*HIC*); the developing countries (*DEV*) included in the WIOD; and the *RoW* (i.e. mainly the aggregate for the developing world). According to the results reported in Table 8, the negative impact of import intensity on wages is much higher when inputs employed along the production chain are from the developing countries and/or *RoW* (columns 2 and 3), than when GII is measured with GVC imports from HIC (column 1). Such a result indicates that the process of transferring production to low-income (thus, low-wage) countries, which are characterised by a lower cost of production, and then importing inputs from them along the sequential production chain force native workers to accept lower wages. Such a result is much weaker when we consider only GVC imports from less competitive, HIC (column 1).

[Table 8 about here]

Given that our sample consists of workers from different countries and sectors, we also explore these sources of the results' heterogeneity. According to the estimations of eq. 2 conducted on the sample splits, the negative and statistically significant effect of GII on wages concerns mainly workers from Western European countries (Table 9), and the effect is much more pronounced for workers employed in construction and manufacturing than for services (Table 10).

[Table 9 about here]

[Table 10 about here]

Further, we simultaneously consider diverse sources of heterogeneity. Table 11 reports the results for subsamples of workers from different European countries and when GII is differentiated according to the source of inputs along the value chain. The negative association between GII and wages is confirmed for workers from Western Europe, and its magnitude is the highest when the GVC inputs are imported from developing countries. Additionally, this negative effect affects Western European workers employed in manufacturing (Table 12).

[Table 11 about here]

[Table 12 about here]

4.2 Economic significance of the results

Based on the results, we conclude that the involvement of domestic industries in production fragmentation, measured globally all along the chain of production, negatively affects mainly the wages of Western European workers (once all other individual, job, country, and sectoral characteristics are controlled).

How strong are the estimated effects in economic terms? In other words, how much have wages in Europe changed due to increased GII? First, remember that the GII index ranges between 0 and 1. Hence, the estimates of log-linear model (2) indicate that an increase in GII by one unit (hence by 1, which is equivalent to an increase of GII by 100%) is associated with a change in hourly wage by $\theta\%$. By considering the results for the entire sample (Europe28), we observe that the greatest estimated coefficient θ is equal to -0.25 (Table 7, column 3). In the context of a registered increase in GVC imports and data on wages in Europe, Table 13 shows the economic significance of the results (based on statistically significant estimates reported in Tables 7, 8, and 11), where we compare the results, split by the source of imports along the GVC, for the entire sample and Western European workers only, typically perceived in the literature as negatively exposed to the effects of production fragmentation.

According to our data, over the sample period *GII* (averaged over all industries), in the whole EU-28, the sample increased from 0.166 (=16.6% of final output) in 2005 to 0.202 (=20.2%) in 2014; hence, GII increased by 0.0354 (=3.54p.p.). Combining it with the coefficient estimate from Table 7 (column 4) and the data on average hourly wage in the initial year (15.75 eur per hour), we find that the change in GVC imports in the period 2005–2014 resulted in an average cumulated wage decrease of only 0.14 eur [=3.54/100*(-0.25)*15.75 eur]. Assuming 1,564 working hours per year (source: EUKLEMS, 2018, EU28_output_17ii), this is equivalent to an annual earnings ‘loss’ of 24 euro. In other words, if the use of inputs along the GVC had remained unchanged with respect to year 2005, the hourly wage of European workers would have been higher by 14 cents in 2014. This effect is not substantial. The magnitude of the effect estimated for Europe28 (Table 13) is almost two times higher if we consider the impact of GVC imports from developing countries.

The picture changes if we consider only workers from Western Europe and the developments in GII there (we do not perform this exercise for Southern Europe or the CEECs because for them, the GII coefficient estimates are statistically insignificant; Table 9). The counterfactual calculations for Western European workers result in a cumulative hourly wage ‘decline’ by 0.2 euro, which is equivalent to 34 euro less in annual earnings. This effect is much greater when we consider the much stronger effect exhibited by GVC imports from developing

countries, including China and India (and measured by GII^{DEV}). If the use of inputs along the GVC from developing countries had remained unchanged with respect to year 2005, the hourly wage of European workers in 2014 would have increased by 1.2 euro (i.e. an annual loss of 209 euro). Hence, the effect of GII of production on wages in Western Europe is not economically negligible.

[Table 13 about here]

4.3 Extensions and robustness checks

We consider many robustness checks and extensions of the basic model estimated for workers from 28 European countries. The general result of the negative effect of GII on the wages of all European workers is robust to how we measure our dependent variable (Table 3A in the appendix), changes in the weighting scheme adopted in the regression (Table 4A in the appendix), or a different construction of the routinisation index (Table 5A in the appendix). We considered other measures of job routinisation by substituting our country-specific routinisation index with the global index based on mapping O*NET to ISCO-88 and ISCO-08³² or with the country-specific Routine Intensity Index (RII), built on data from the OECD Programme for the International Assessment of Adult Competencies (PIAAC) survey³³. None of these changes alters our main result in a considerable manner: the negative influence of GII of production on wages of European workers.

Next, although our model incorporates sector and country-specific fixed effects, and thus should capture all other wage determinants not explicitly included into the model, we considered the extended estimations including additional control variables. By following Geishecker et al. (2010) and Schäfer and Gottschall (2015), we consider differences in labour market institutions and country-specific wage bargaining schemes (Table 6A in the appendix). We also include variables related to country-level and industry-level trade openness (Table 7A in the appendix). Confirming other studies (e.g. Hummels et al, 2014), the more export-oriented sectors (with a higher share of export to value added) are characterised by higher wages. In line with the literature on the role of technology in wage determination (Autor et al., 2003; Acemoglu and Autor, 2011; Goos et al., 2014), we also consider the potential role played by technology and R&D (we employ industry-level variables on computing, communications, and R&D equipment, expressed either as capital formation or stock; Table 8A in the appendix). The inclusion of

³² Codes for occupation classifications crosswalks – from O*NET-SOC to ISCO provided by the Institute for Structural Research, www.ibs.org.pl/resources/

³³ We would like to thank Luca Marcolin from OECD for sharing the data. For details on their RII see Marcolin et al. (2016).

additional country-specific or sector-specific variables does not change our main results and, notably, those additional variables are hardly statistically significant. Finally, our results are also not influenced by a specific country or industry (we assessed this influence by eliminating, one-by-one, countries or industries from the sample, and the results over such limited subsamples showing mean and the minimum and maximum coefficients are reported in Tables 9A and 10A in the appendix).

Finally, we split the time of our analysis into pre and post crises; respectively, we run regressions for two time periods: 2005–2008 and 2009–2014. As indicated in Table 11A, in the years before the crisis, when the growth of GII was more intensive than afterwards, the effect on wages was two times higher than in the years after 2009, when the slowdown of GII growth was observed (Timmer et al., 2016).

As our study is the first to employ GII to measure global dependence on foreign inputs, it is thus notable to compare our results to the results obtained with a conventional measure of offshoring. To perform this task, we compared our results with those obtained with a measure of GII, taking into account only the import intensity of production measured at the last stage of production. Such a measure is more similar to the classic offshoring indicator commonly employed in the literature on the effects of production sharing on wages. The results (Table 12A in the appendix) are notable and show that the effects of the use of foreign inputs on the previous stages of the production on wages of native workers might be cumulative and hence higher than those of the last tier of production only.

[all the Tables referring to this section are in the appendix]

5. Conclusions

This paper attempts to contribute to the empirical literature on the microeconomic consequences of cross-border production links for European workers. We address several limits of single-country studies on offshoring/production fragmentation and wages. For the first time, we use the micro-level data matched with industrial statistics for 28 European countries to draw conclusions on the wage effects of global production links on (almost) the entire labour market of the European Union. We considered differences in countries' level of development or labour market institutions, sectoral specificity, and the heterogeneity of foreign inputs according to source countries' characteristics; we considered the country-specific task content of jobs affecting wage levels. We measured fragmentation within GVCs (GII - global import intensity of production computed with newest 2016 World Input–Output Database) in a manner that

allowed us to trace back the involvement of sectors into the global structure of production. Consequently, we posit this perspective is the broadest European perspective adopted to the study of wage response to global production links, and our conclusions are not country specific, like in many related papers.

By using our unique, linked micro-sectoral data for workers from 28 European countries, we estimate several wage models augmented by a global backward measure of participation in production fragmentation. GII of production, by contrast with conventional measures of offshoring, captures the imports of goods and services required in any stage of the production of the final product and involves third-country trade. Such a view is more coherent with the key feature of GVC observed as a cross-country multistage production network that results in cross-country industrial interdependence.

In general, in the whole sample of 28 European countries, we observe a negative effect of the use of major GVC imports on wages. This effect, calculated over the whole sample of workers, is not very strong in economic terms. However, our results suggest significant heterogeneity with respect to subsamples of European countries and the source of imports along the value chain of production. The negative pressure on wages concerns mainly workers from Western Europe employed in manufacturing and is driven by production links with developing countries. We performed a counterfactual exercise to estimate the magnitude of this effect: The counterfactual calculations for Western European workers result in a cumulative hourly wage ‘decline’ by 0.2 euro, which is equivalent to 34 euro less in annual earnings over the sample period (2005–2014). This effect is much greater when we consider the much stronger impact exhibited by GVC imports from developing countries, including China and India. *Ceteris paribus* if the use of inputs along the GVC coming from developing countries had remained unchanged with respect to year 2005, the hourly wage of Western European workers in 2014 would have been higher by 1.2 euro (an annual loss of 209 euro). In the case of workers from Southern Europe or from the CEECs, we do not reveal strong statistically significant effects of GII of production on wages. In these countries, wages are mainly determined by the personal characteristics of the workers including the level of routinisation of their job.

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Tables and Figures

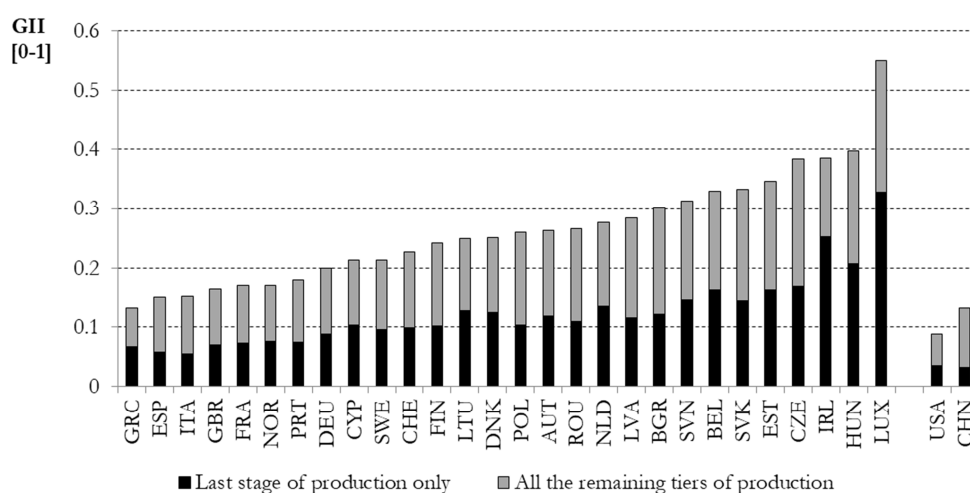
Table 1. Global import intensity of production, as % of final output (World, Europe, USA)

	Last stage of production			All tiers of production (GII)		
	World	Europe(28)*	USA	World	Europe (28)*	USA
2000	5.2	7.4	2.8	11.8	15.9	7.9
2014	6.3	8.8	3.5	15.8	20.2	8.8

Notes: *average values calculated across 56 industries and weighted by industrial value added (VA_{ijt}). GII calculated as in eq. 1, GII reflects the ratio of GVC imports to the output of the final products and ranges here between 0 and 100%. The list of industries in Table 1A in the Appendix. Europe (28) consists of: *W* - Western Europe (AT, BE, CH, DE, DK, FI, FR, IE, IT, NL, NO, SE, UK); *S*- Southern Europe (CY, ES, EL, PT); *CEECs*- Central and Eastern European Countries (BG, CZ, EE, HU, LT, LU, LV, PL, RO, SI, SK).

Source: own calculations based on WIOD (release Nov 2016) and Timmer et al. (2016) methodology.

Figure 1. Global import intensity of production (GII, index 0-1) – 28 European countries versus the U.S. and China



Notes: average values calculated across 56 industries and weighted by industrial value added (VA_{ijt}). GII calculated as in eq. 1. GII is a sum of the values for the last stage of production only and of all the remaining tiers of production. 28 European countries (Europe 28) included in the sample: *W* - Western Europe (AT, BE, CH, DE, DK, FI, FR, IE, IT, NL, NO, SE, UK); *S*- Southern Europe (CY, ES, EL, PT); *CEECs*- Central and Eastern European Countries (BG, CZ, EE, HU, LT, LU, LV, PL, RO, SI, SK).

Source: own calculations based on WIOD (release Nov 2016) and Timmer et al. (2016) methodology.

Table 2. Global import intensity of production (GII, index 0-1), 2014 – by sectors

Country sample:	all industries	agriculture	construction	manufacturing	services
World	0.16	0.13	0.24	0.29	0.11
Europe28	0.20	0.29	0.29	0.42	0.13
Western Europe (<i>W</i>)	0.20	0.30	0.29	0.41	0.14
Southern Europe (<i>S</i>)	0.15	0.20	0.22	0.40	0.09
<i>CEECs</i>	0.30	0.33	0.38	0.54	0.19

Notes: *average values weighted by industrial value added (VA_{ijt}), the list of industries in Table 1A in the Appendix. GII calculated as in eq. 1. Country groups: *W* - Western Europe (AT, BE, CH, DE, DK, FI, FR, IE, IT, NL, NO, SE, UK); *S*- Southern Europe (CY, ES, EL, PT); *CEECs*- Central and Eastern European Countries (BG, CZ, EE, HU, LT, LU, LV, PL, RO, SI, SK).

Source: own calculations based on WIOD (release Nov 2016) and Timmer et al. (2016) methodology

Table 3. Global import intensity of production (GII), 2014 – split by the source of intermediate inputs along the value chain (GII^{HIC} and GII^{DEV})

Panel A.		GII^{HIC}			
Country sample:	all industries	agriculture	construction	manufacturing	services
World	0.09	0.07	0.14	0.16	0.06
Europe28	0.14	0.20	0.21	0.31	0.10
Western Europe (W)	0.14	0.21	0.21	0.30	0.10
Southern Europe (S)	0.09	0.12	0.14	0.25	0.06
CEECs	0.21	0.23	0.27	0.37	0.14
Panel B.		GII^{DEV}			
Country sample:	all industries	agriculture	construction	manufacturing	services
world	0.03	0.03	0.05	0.06	0.02
Europe28	0.02	0.04	0.04	0.06	0.02
Western Europe (W)	0.02	0.04	0.04	0.05	0.02
Southern Europe (S)	0.02	0.03	0.03	0.06	0.01
CEECs	0.04	0.05	0.06	0.09	0.03
Panel C.		GII^{RoW}			
Country sample:	all industries	agriculture	construction	manufacturing	services
world	0.03	0.03	0.05	0.07	0.02
Europe28	0.03	0.05	0.04	0.06	0.02
Western Europe (W)	0.04	0.05	0.03	0.05	0.02
Southern Europe (S)	0.03	0.05	0.04	0.10	0.02
CEECs	0.04	0.05	0.04	0.07	0.03

Notes: as under Table 1. *HIC* (high income countries)=AUS, AUT, BEL, CAN, HRV, CYP, CZE, DNK, EST, FIN, FRA, DEU, GRC, HUN, IRL, ITA, JPN, KOR, LVA, LTU, LUX, MLT, NLD, NOR, POL, PRT, SVK, SVN, ESP, SWE, CHE, TWN, GBR, USA; *DEV* (developing countries)= BRA, BGR, CHN, IND, IDN, MEX, ROM, RUS, TUR; *RoW*=world – 43 countries present in WIOD2016 = world – *HIC* – *DEV*.

Source: own calculations based on WIOD (release Nov 2016) and Timmer et al. (2016) methodology.

Table 4. Import intensity of production based on first tier imports only (GII_tier1) and including all imports in the GVC (GII) – by country (Europe28)

Country	<i>GII</i>		<i>GII_tier1</i>	
	2005	2014	2005	2014
Western Europe (W)				
AT	0.23	0.26	0.11	0.12
BE	0.26	0.33	0.13	0.16
CH	0.21	0.23	0.09	0.10
DE	0.16	0.20	0.07	0.09
DK	0.22	0.25	0.11	0.12
FI	0.22	0.24	0.09	0.10
FR	0.14	0.17	0.06	0.07
UK	0.14	0.16	0.07	0.07
IE	0.31	0.39	0.18	0.25
IT	0.13	0.15	0.05	0.06
LU	0.47	0.55	0.28	0.33
NL	0.21	0.28	0.11	0.14
NO	0.14	0.17	0.06	0.08
SE	0.21	0.21	0.10	0.10
Southern Europe (S)				
CY	0.20	0.21	0.10	0.10
ES	0.16	0.15	0.06	0.06
EL	0.12	0.13	0.06	0.07
PT	0.17	0.18	0.07	0.07
Central&Eastern Europe (CEECs)				
BG	0.27	0.30	0.11	0.12
CZ	0.29	0.38	0.12	0.17
EE	0.31	0.35	0.15	0.16
HU	0.30	0.40	0.15	0.21
LT	0.22	0.25	0.11	0.13
LV	0.25	0.28	0.11	0.12
PL	0.21	0.26	0.09	0.10
RO	0.24	0.27	0.11	0.11
SI	0.27	0.31	0.12	0.15
SK	0.31	0.33	0.14	0.15

Notes: *average values calculated across 56 industries (the list of industries in Table 1A in the Appendix) and weighted by industrial value added (VA_{ijt}). *GII* calculated as in eq. 1.

Source: own calculations based on WIOD (release Nov 2016) and Timmer et al. (2016) methodology.

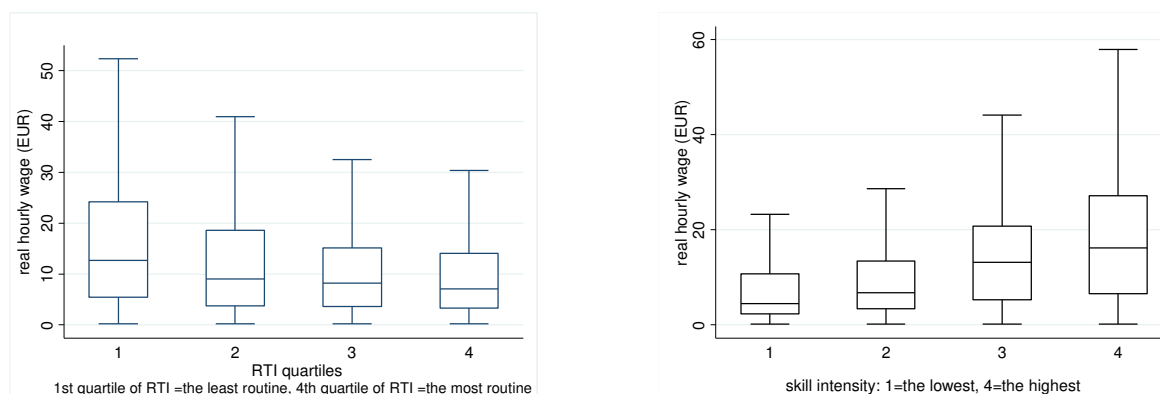


Figure 2. Wages by job routinisation intensity and by skill intensity (Europe 28, 2014)

Source: own calculations based on EU-SILC. RTI quartiles based on country-specific indices of job routinisation from Hardy et al (2018a), skill categories based on mapping main ISCO groups into skill groups according to ILO (2012).

Table 5. Wages by job routinisation intensity (Western Europe, Southern Europe and CEECs, 2014)

Country sample:	RTI quartile 1 (=the least routine)	RTI quartile 2	RTI quartile 3	RTI quartile 4 (=the most routine)
Western Europe (W)	23.87	18.92	14.74	14.20
Southern Europe (S)	14.98	10.51	9.10	7.74
CEECs	5.13	3.20	3.25	3.04

Note: RTI quartiles based on country-specific indices of routine task intensity of occupations from Hardy et al (2018a).

Source: own calculations based on EU-SILC.

Table 6. Estimation results (1) – GII among other determinants of wages in Europe

	OLS (1)	OLS (2)	IV (3)	IV (4)
Dep.var: log hourly wage (gross)				
Sex (=1 if male)	0.173*** [0.008]	0.168*** [0.008]	0.173*** [0.008]	0.168*** [0.008]
Age (years)	0.048*** [0.003]	0.040*** [0.003]	0.048*** [0.003]	0.040*** [0.003]
Age ²	-0.000*** [0.000]	-0.000*** [0.000]	-0.000*** [0.000]	-0.000*** [0.000]
Marital status (=1 if married)	0.032*** [0.003]	0.025*** [0.003]	0.031*** [0.003]	0.025*** [0.003]
Education (=1 if high)	0.214*** [0.008]	0.205*** [0.008]	0.214*** [0.008]	0.205*** [0.008]
Firm size (=1 if big)	0.255*** [0.010]	0.194*** [0.008]	0.256*** [0.010]	0.195*** [0.008]
Firm size (=1 if medium)	0.160*** [0.009]	0.100*** [0.007]	0.160*** [0.009]	0.101*** [0.007]
ln_Prod (VA/H)	0.111*** [0.032]	0.130*** [0.030]	0.108*** [0.032]	0.128*** [0.030]
<i>RTI</i>	-0.387*** [0.011]	-0.356*** [0.011]	-0.388*** [0.011]	-0.356*** [0.011]
<i>GII [0-1]</i>	-0.153* [0.079]	-0.152* [0.082]	-0.250*** [0.080]	-0.229*** [0.083]
Job contract (=1 if permanent)		0.216*** [0.018]		0.216*** [0.018]
Job position (=1 if managerial)		0.126*** [0.004]		0.126*** [0.004]
R ²	0.76	0.8	0.76	0.8
N	1217953	1105538	1213922	1101866
Under-identification			0.00	0
Weak identification			640.2	616.4

Notes: normalised weighted regression with robust standard errors (in parentheses), clustered at the country-industry level, the weights are based on personal cross-sectional weights (from EU-SILC) normalised by the number of observation per country (see main text for the details); * $p \leq .10$, ** $p \leq .05$, *** $p \leq .01$. In specification (3) and (4) GII is treated as an endogenous variable, see the main text for the explanation of instrument construction. The figures reported for the under-identification test are the p-values and refer to the Kleibergen-Paap rk LM test statistic, where a rejection of the null indicates that the instruments are not under-identified. The weak identification test refers to the Kleibergen-Paap Wald rk F statistic test for the presence of weak instruments. As a 'rule of thumb' the statistic should be at least 10 for weak identification not to be considered a problem (Staiger and Stock, 1997).

Source: own elaboration based on data from EU-SILC and WIOD.

Table 7. Estimation results (2) – GII as wage determinant in Europe, robustness with respect to the set of control variables

Dep.var: log hourly wage (gross)	(1)	(2)	(3)	(4)
<i>RTI</i>	-0.545*** [0.013]	-0.542*** [0.013]	-0.391*** [0.010]	-0.388*** [0.011]
<i>GII [0-1]</i>	-0.230** [0.089]	-0.194** [0.080]	-0.209*** [0.079]	-0.250*** [0.080]
Personal controls	no	no	yes	yes
Employment controls	no	no	no	yes
Industry characteristics	no	yes	yes	yes
Time dummies p-value	0.000	0.000	0.000	0.000
Country dummies p-value	0.000	0.000	0.000	0.000
Industry dummies p-value	0.000	0.000	0.000	0.000
R ²	0.73	0.73	0.76	0.76
N	1312076	1312076	1304717	1213922
Under-identification	0.000	0.000	0.000	0.000
Weak identification	628.77	649.2	642.98	640.2

Notes: normalised weighted regression with robust standard errors (in parentheses), clustered at the country-industry level, the weights are based on personal cross-sectional weights (from EU-SILC) normalised by the number of observation per country (see main text for the details); * $p \leq .10$, ** $p \leq .05$, *** $p \leq .01$. *Personal controls* include: age, age2, marital status, education (the default category for education are non-high (medium /low-educated workers)), *Employment controls* refer to the size of the entities: the default category are small firms, *Industry characteristics* refer to the productivity of industry calculated as the ratio of real value added of the industry to the total number of hours worked by employees (source WIOD, 2016). GII is treated as an endogenous variable, see the main text for the explanation of instrument construction. In all specifications time, country and industry dummies are included, p-values for the Wald tests of hypothesis that dummies' coefficients are zero. The figures reported for the under-identification test are the p-values and refer to the Kleibergen-Paap rk LM test statistic, where a rejection of the null indicates that the instruments are not under-identified. The weak identification test refers to the Kleibergen-Paap Wald rk F statistic test for the presence of weak instruments. As a 'rule of thumb' the statistic should be at least 10 for weak identification not to be considered a problem (Staiger and Stock, 1997).

Source: own elaboration based on data from EU-SILC and WIOD.

Table 8. Estimation results (3) - GII as wage determinant in Europe, split according to the source of imports along the value chain

Dep.var: log hourly wage (gross)	GII – imports coming from:		
	high income countries (<i>HIC</i>) (1)	developing countries (<i>DEV</i>) (2)	rest of the world (<i>RoW</i>) (3)
<i>RTI</i>	-0.389*** [0.011]	-0.387*** [0.011]	-0.390*** [0.011]
<i>GII [0-1]</i>	-0.333*** [0.105]	-1.709** [0.838]	-1.818** [0.778]
R ²	0.77	0.76	0.76
N	1207394	1207394	1207112
Under-identification	0.000	0.000	0.000
Weak identification	418235.8	22466.7	43613.84

Notes: as under Table 7. Personal and employment controls, industry characteristics (productivity), time, country and industry dummies included in all models. *HIC* (*high income countries*)=AUS, AUT, BEL, CAN, HRV, CYP, CZE, DNK, EST, FIN, FRA, DEU, GRC, HUN, IRL, ITA, JPN, KOR, LVA, LTU, LUX, MLT, NLD, NOR, POL, PRT, SVK, SVN, ESP, SWE, CHE, TWN, GBR, USA; *DEV* (*developing countries*)= BRA, BGR, CHN, IND, IDN, MEX, ROM, RUS, TUR; *RoW*=world – 43 countries present in WIOD2016 = world – *HIC-DEV*.

Source: own elaboration based on data from EU-SILC and WIOD

Table 9. Estimation results (4) - GII as wage determinant in Europe, cross-country heterogeneity

Dep.var: log hourly wage (gross)	Sample: workers from		
	Western Europe (1)	Central and Eastern Europe (2)	Southern Europe (3)
<i>RTI</i>	-0.319*** [0.010]	-0.426*** [0.013]	-0.585*** [0.048]
<i>GII [0-1]</i>	-0.278** [0.111]	0.033 [0.093]	-0.018 [0.247]
R ²	0.4	0.54	0.5
N	529542	529836	154544
Under-identification	0.000	0.000	0.000
Weak identification	758174.8	1422226	82804.93

Notes: as under Table 7. Personal and employment controls, industry characteristics (productivity), time, country and industry dummies included in all models.

Source: own elaboration based on data from EU-SILC and WIOD.

Table 10. Estimation results (5) - GII as wage determinant in Europe, cross-industry heterogeneity

Dep.var: log hourly wage (gross)	Workers employed in:			
	agriculture (1)	construction (2)	manufacturing (3)	services (4)
<i>RTI</i>	-0.261*** [0.036]	-0.319*** [0.024]	-0.365*** [0.019]	-0.405*** [0.014]
<i>GII [0-1]</i>	0.162 [0.747]	-1.021** [0.421]	-0.598* [0.316]	-0.169* [0.094]
R ²	0.53	0.72	0.81	0.76
N	30835	95714	292230	795143
Under-identification	0.000	0.02	0.000	0.000
Weak identification	21.91	114.33	291.92	1018331

Notes: as under Table 7. Personal and employment controls, industry characteristics (productivity), time and country dummies included in all models.

Source: own elaboration based on data from EU-SILC and WIOD.

Table 11 Estimation results (6) - GII as wage determinant in different European countries, accounting for the source of imports along the value chain

Dep.var: log hourly wage (gross)	GII – imports coming from:		
	high income countries (<i>HIC</i>)	developing countries (<i>DEV</i>)	rest of the world (<i>RoW</i>)
Workers from Western Europe	(1)	(2)	(3)
<i>RTI</i>	-0.319*** [0.011]	-0.319*** [0.011]	-0.320*** [0.011]
<i>GII [0-1]</i>	-0.314** [0.135]	-6.645** [3.115]	-2.482** [0.967]
R ²	0.4	0.39	0.4
N	523719	523719	526119
Under-identification	0.00	0.00	0.00
Weak identification	513.74	10.55	32.36
Workers from CEECs	(1)	(2)	(3)
<i>RTI</i>	-0.426*** [0.013]	-0.426*** [0.013]	-0.426*** [0.013]
<i>GII [0-1]</i>	0.045 [0.148]	0.21 [0.384]	0.868 [0.939]
R ²	0.54	0.54	0.54
N	529131	529131	526449
Under-identification	0.00	0.00	0.00
Weak identification	67.15	26.64	32.04
Workers from Southern Europe	(1)	(2)	(3)
<i>RTI</i>	-0.585*** [0.049]	-0.585*** [0.048]	-0.586*** [0.048]
<i>GII [0-1]</i>	-0.339 [0.324]	0.973 [2.078]	0.986 [1.379]
R ²	0.5	0.5	0.5
N	154544	154544	154544
Under-identification	0.00	0.05	0.00
Weak identification	47.51	6.41	27.63

Notes: as under Table 7. Personal and employment controls, industry characteristics (productivity), time, country and industry dummies included in all models.

Source: own elaboration based on data from EU-SILC and WIOD

Table 12. Estimation results (7) - GII as wage determinant in different country subgroups, cross-industry heterogeneity

Dep.var: log hourly productivity	Workers employed in			
	agriculture	construction	manufacturing	services
Workers from Western Europe	(1)	(2)	(3)	(4)
RTI	-0.093 [0.082]	-0.265*** [0.038]	-0.311*** [0.019]	-0.331*** [0.013]
<i>GII [0-1]</i>	1.107 [1.334]	-0.333 [0.454]	-0.637** [0.307]	-0.197 [0.126]
R ²	0.27	0.31	0.43	0.4
N	9366	39574	111425	369177
Under-identification	0.04	0.01	0.01	0.000
Weak identification	11.83	12.54	197.97	1308.54
Workers from CEECs	(1)	(2)	(3)	(4)
RTI	-0.289*** [0.020]	-0.329*** [0.016]	-0.414*** [0.023]	-0.441*** [0.018]
<i>GII [0-1]</i>	0.558 [0.636]	-1.135** [0.464]	0.179 [0.626]	0.206 [0.141]
R ²	0.43	0.43	0.58	0.54
N	18081	42226	153705	315824
Under-identification	0.05	0.02	0.01	0.000
Weak identification	173.28	476.62	212.32	2706.25
Workers from Southern Europe	(1)	(2)	(3)	(4)
RTI	-0.410*** [0.150]	-0.514*** [0.088]	-0.432*** [0.072]	-0.692*** [0.067]
<i>GII [0-1]</i>	-1.793 [1.708]	-0.427 [0.496]	-0.899** [0.396]	-0.16 [0.283]
R ²	0.25	0.37	0.49	0.49
N	3388	13914	27100	110142
Under-identification	0.17	0.08	0.13	0.01
Weak identification	417.78	46.51	528.91	323.1

Notes: as under Table 7. Personal and employment controls, industry characteristics (productivity), time and country dummies included in all models.

Source: own elaboration based on data from EU-SILC and WIOD.

Table 13. Economic significance calculations

Sample: workers from EU28									
		<i>GII</i>		<i>GII^{HIC}</i>		<i>GII^{DEV}</i>		<i>GII^{RoW}</i>	
Estimated coefficient <i>GII</i> *		-0.25		-0.33		-1.7		-1.8	
Change in <i>GII</i> 2005-2014 (in p.p.)		3.54		1.82		0.93		0.78	
Average hourly wage in 2005 (in eur)	15.75								
		percent	euro	percent	euro	percent	euro	percent	euro
cumulative economic effect on hourly wage		-0.01	-0.14	-0.01	-0.09	-0.02	-0.25	-0.01	-0.22
average annual affect on earnings			-24.22		-16.44		-43.27		-38.43
Sample: workers from Western Europe									
		<i>GII</i>		<i>GII^{HIC}</i>		<i>GII^{DEV}</i>		<i>GII^{RoW}</i>	
Estimated coefficient <i>GII</i> **		-0.28		-0.314		-6.64		-2.48	
Change in <i>GII</i> 2005-2014 (in p.p.)		3.69		2		0.94		0.74	
Average hourly wage in 2005 (in eur)	19.28								
		percent	euro	percent	euro	percent	euro	percent	euro
cumulative economic effect on hourly wage		-0.01	-0.20	-0.01	-0.12	-0.06	-1.20	-0.02	-0.35
average annual affect on earnings			-34.37		-21.04		-209.12		-61.49

Note: *results from Table 7 and Table 8; **results from Table 9 and Table 11

Source: own calculations based on EU-SILC and WIOD.

Appendix

Table 1A. List of industries in WIOD release 2016 (according to ISIC Rev. 4) used for the calculation of GII

1	A01	Crop and animal production, hunting and related service activities
2	A02	Forestry and logging
3	A03	Fishing and aquaculture
4	B	Mining and quarrying
5	C10-C12	Manufacture of food products, beverages and tobacco products
6	C13-C15	Manufacture of textiles, wearing apparel and leather products
7	C16	Manufacture of wood and of products of wood and cork, except furniture; etc.
8	C17	Manufacture of paper and paper products
9	C18	Printing and reproduction of recorded media
10	C19	Manufacture of coke and refined petroleum products
11	C20	Manufacture of chemicals and chemical products
12	C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations
13	C22	Manufacture of rubber and plastic products
14	C23	Manufacture of other non-metallic mineral products
15	C24	Manufacture of basic metals
16	C25	Manufacture of fabricated metal products, except machinery and equipment
17	C26	Manufacture of computer, electronic and optical products
18	C27	Manufacture of electrical equipment
19	C28	Manufacture of machinery and equipment n.e.c.
20	C29	Manufacture of motor vehicles, trailers and semi-trailers
21	C30	Manufacture of other transport equipment
22	C31_C32	Manufacture of furniture; other manufacturing
23	C33	Repair and installation of machinery and equipment
24	D	Electricity, gas, steam and air conditioning supply
25	E36	Water collection, treatment and supply
26	E37-E39	Sewerage; waste collection, treatment and disposal activities; materials recovery; etc.
27	F	Construction
28	G45	Wholesale and retail trade and repair of motor vehicles and motorcycles
29	G46	Wholesale trade, except of motor vehicles and motorcycles
30	G47	Retail trade, except of motor vehicles and motorcycles
31	H49	Land transport and transport via pipelines
32	H50	Water transport
33	H51	Air transport
34	H52	Warehousing and support activities for transportation
35	H53	Postal and courier activities
36	I	Accommodation and food service activities
37	J58	Publishing activities
38	J59_J60	Motion picture, video and television programme production, sound recording and music publishing activities; etc.
39	J61	Telecommunications
40	J62_J63	Computer programming, consultancy and related activities; information service activities
41	K64	Financial service activities, except insurance and pension funding
42	K65	Insurance, reinsurance and pension funding, except compulsory social security
43	K66	Activities auxiliary to financial services and insurance activities
44	L	Real estate activities
45	M69_M70	Legal and accounting activities; activities of head offices; management consultancy activities
46	M71	Architectural and engineering activities; technical testing and analysis
47	M72	Scientific research and development
48	M73	Advertising and market research
49	M74_M75	Other professional, scientific and technical activities; veterinary activities
50	N	Rental and leasing activities, Employment activities, Travel services, security and services to buildings
51	O	Public administration and defence; compulsory social security
52	P	Education
53	Q	Human health and social work activities
54	R-S	Creative, Arts, Sports, Recreation and entertainment activities and all other personal service activities
55	T	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use
56	U	Activities of extra-territorial organisations and bodies

Table 2A. Summary statistics of micro-level variables

	variable	n	mean	st.dev.	min	max
Dependent variable – <i>gross hourly wage [EUR, real]</i>	<i>wage1</i>	546964	12.31	10.04	0.01	113.46
	<i>wage2</i>	1377903	13.95	10.93	0.08	160.36
Personal characteristics	<i>Sex</i> (male=1)	1377903	0.60	0.49	0.00	1.00
	<i>Age</i> (age, in years)	1377903	40.94	11.10	18.00	65.00
	<i>Exp</i> (experience, in years)	1013152	19.21	11.63	0.00	65.00
	<i>Mededuc</i> (medium education completed)	1370211	0.64	0.48	0.00	1.00
	<i>Hieduc</i> (high education completed)	1370211	0.32	0.47	0.00	1.00
	<i>Married</i> (family status)	1377903	0.56	0.50	0.00	1.00
Job characteristics	<i>MicroFirm</i> (company size: micro, 1-10)	1342522	0.22	0.41	0.00	1.00
	<i>SizeMed</i> (company size: medium, 11-49)	1280416	0.28	0.45	0.00	1.00
	<i>SizeBig</i> (company size: big, >=50)	1280416	0.49	0.50	0.00	1.00
	<i>Cont_Perm</i> (permanent contract)	1239555	0.89	0.31	0.00	1.00
	<i>Cont_Temp</i> (temporary contract)	1239555	0.11	0.31	0.00	1.00
	<i>Manag</i> (managerial position)	1261068	0.28	0.45	0.00	1.00

Note. *n* varies due to limited availability of some of the variables, observations weighted by personal cross-sectional weights.

Source: authors' calculations with EU-SILC data

Table 3A. Estimation results – GII as wage determinant in Europe, robustness with respect to the way the dependent variable is measured*

Dep.var: log hourly wage (gross)*	(1)	(2)	(3)	(4)
<i>RTI</i>	-0.566*** [0.017]	-0.565*** [0.017]	-0.409*** [0.013]	-0.400*** [0.013]
<i>GII [0-1]</i>	-0.286*** [0.107]	-0.299*** [0.105]	-0.317*** [0.099]	-0.363*** [0.097]
Personal controls	no	no	yes	yes
Employment controls	no	no	no	yes
Industry characteristics	no	yes	yes	yes
Time dummies	0.000	0.000	0.000	0.000
Country dummies	0.000	0.000	0.000	0.000
Industry dummies	0.000	0.000	0.000	0.000
R ²	0.79	0.79	0.83	0.83
N	528701	528701	524150	481348
Under-identification	0.00	0.00	0.00	0.00
Weak identification	659.85	751.38	746.61	743.57

Notes: as under Table 7. * gross hourly wage obtained here from the information on monthly gross earnings and the number of hours worked per week.

Source: own elaboration based on data from EU-SILC and WIOD.

Table 4A. Estimation results – GII as wage determinant in Europe, robustness with respect to the weighting scheme adopted in the regression

Dep.var: log hourly wage (gross)	Weight type:		
	weights 1	weights 2	weights 3
	(1)	(2)	(3)
<i>RTI</i>	-0.388*** [0.011]	-0.387*** [0.009]	-0.389*** [0.009]
<i>GII [0-1]</i>	-0.250*** [0.080]	-0.159** [0.077]	-0.179** [0.079]
R ²	0.76	0.75	0.74
N	1213922	1213922	1213922
Under-identification	0.00	0.00	0.00
Weak identification	640.2	687.05	590.11

Notes: as under Table 7. Country, industry and time dummies included. Weighted regression, normalised weights with different scaling methods: weight 1 – benchmark weights: normalised personal weights, which always sums to 10 000 within each country, weights 2: normalised personal weights by number of observations according to inverse probability, as in Rabe-Hesketh and Skrondal, (2006); weights 3: personal weights normalised by country mean (mean of weights by country = 1).

Source: own elaboration based on data from EU-SILC and WIOD

Table 5A. Estimation results – GII as wage determinant in Europe, robustness with respect to the way job routinisation is measured

Dep.var: log hourly wage (gross)	Routinisation index		
	RTI (1)	RTI (2)	RTI (3)
	(1)	(2)	(3)
RTI	-0.388***	-0.677***	-0.123***
	[0.011]	[0.019]	[0.005]
<i>GII [0-1]</i>	-0.250***	-0.223***	-0.203**
	[0.080]	[0.078]	[0.079]
R ²	0.76	0.76	0.76
N	1213922	1214237	1214237
Under-identification	0.00	0.00	0.00
Weak identification	640.2	639.8	640.05

Notes: as under Table 7. Country, industry and time dummies included in all specifications. RTI (1) – country-specific benchmark index, as in the main text according to Hardy et al. 2018a, RTI (2) – global index based on mapping O*NET – SOC (version: 20.1 O*NET dataset release (2015)) to ISCO-88 and ISCO-08 (codes for occupation classifications crosswalks provided by the Institute for Structural Research, www.ibs.org.pl/resources/); RTI (3) country-specific Routine Intensity Indicator (RII), built on data from the OECD Programme for the International Assessment of Adult Competencies (PIAAC) survey, according to Marcolin et al., 2016.

Source: own elaboration based on data from EU-SILC and WIOD

Table 6A. Estimation results – GII as wage determinant in Europe, specification with additional country-level variables describing wage bargaining measures

	<i>coord</i>	<i>nms</i>	<i>nmw</i>	<i>sector</i>	<i>type</i>	<i>ud</i>	<i>unagr</i>	<i>wage</i>	<i>wage_max</i>	<i>wage_proc</i>	<i>wc</i>	<i>negot</i>	<i>rights</i>	<i>hrs</i>	<i>unempl</i>
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
RTI	-0.388***	-0.388***	-0.388***	-0.389***	-0.389***	-0.379***	-0.389***	-0.387***	-0.387***	-0.387***	-0.389***	-0.389***	-0.389***	-0.387***	-0.388***
	[0.011]	[0.011]	[0.011]	[0.011]	[0.011]	[0.011]	[0.011]	[0.011]	[0.011]	[0.011]	[0.011]	[0.011]	[0.011]	[0.011]	[0.011]
<i>GII[0-1]</i>	-0.240***	-0.246***	-0.248***	-0.249***	-0.239***	-0.281***	-0.250***	-0.249***	-0.247***	-0.248***	-0.250***	-0.247***	-0.249***	-0.248***	-0.256***
	[0.080]	[0.080]	[0.080]	[0.081]	[0.080]	[0.084]	[0.081]	[0.080]	[0.080]	[0.080]	[0.081]	[0.081]	[0.081]	[0.080]	[0.079]
Wage Bargaining	0.021***	0.005	-0.015	0.016	0.005	-0.006**	0.065**	-0.013	0.013**	0.006	0.099***	0.003	0.036***	0.003	-0.007***
	[0.005]	[0.006]	[0.016]	[0.016]	[0.004]	[0.002]	[0.028]	[0.011]	[0.006]	[0.010]	[0.022]	[0.011]	[0.011]	[0.018]	[0.001]
R ²	0.77	0.76	0.76	0.77	0.75	0.75	0.77	0.76	0.76	0.76	0.77	0.77	0.77	0.76	0.77
N	1213922	1202974	1202974	1197623	1184789	960956	1197623	1200152	1200152	1200152	1199149	1199149	1199149	1200152	1213922
Under	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Weak	636.43	608.65	609.58	613.81	634.41	638.04	614.72	610.11	610.01	610.11	616.39	612.86	616.72	609.86	640.65

Notes: as under Table 7. Country, industry and time dummies included.

Wage bargaining, source Visser (2016) ICTWSS Database version 5.1: *coord* - coordination of wage-setting; *nms* - Minimum Wage Setting; *nmw* - National Minimum Wage; *sector* - Sectoral organization of employment relations; *type* - type of coordination of wage setting ; *ud* - union density rate, net union membership as a proportion of wage earners in employment ; *unagr* - union (affiliate) role in wage bargaining; *wage* - pact or agreement is about wage issues; *wage_max* - pact or agreement contains a norm or ceiling regarding maximum wage rise; *wage_proc* - pact or agreement is about procedure for wage setting; *wc* - status of works council; *negot* - involvement of works councils (or similar structures) in wage negotiations; *rights* - rights of works councils; *hrs* - pact or agreement contains, and/or is predicated on, concessions regarding working hours. *Unempl* - unemployment, % of total labor force, source: WDL.

Source: own elaboration based on data from EU-SILC and WIOD

Table 7A. Estimation results – GII as wage determinant in Europe, specification with additional country or sector-level variables describing openness

Dep.var: log hourly wage (gross)	Openness measure:		
	Export_GDP	Import_GDP	Export_Sector
	(1)	(2)	(3)
<i>RTI</i>	-0.388***	-0.388***	-0.389***
	[0.011]	[0.011]	[0.011]
<i>GII[0-1]</i>	-0.246***	-0.233***	-0.457***
	[0.080]	[0.081]	[0.129]
<i>Openness</i>	-0.001	-0.002***	0.051**
	[0.001]	[0.001]	[0.024]
R ²	0.77	0.77	0.76
N	1213922	1213922	1213922
Under-identification	0.000	0.000	0.000
Weak identification	636.51	631.27	302.43

Notes: as under Table 7 Country, industry and time dummies included.

Openness measures: Export_GDP - Exports of goods and services (% of GDP), source: WDI, Import_GDP - Imports of goods and services (% of GDP), source: WDI, Export_Sector – export to value added of a given sector, source: WDI, WIOD (2016)

Source: own elaboration based on data from EU-SILC and WIOD

Table 8A. Estimation results – GII as wage determinant in Europe, specification with additional technological variables describing technology and R&D

	Technology and R&D measures							
	I_IT	I_CT	I_RD	K_IT	K_CT	K_RD	Kq_IT	Kq_CT
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
<i>RTI</i>	-0.405***	-0.405***	-0.405***	-0.405***	-0.405***	-0.405***	-0.405***	-0.405***
	[0.012]	[0.012]	[0.012]	[0.012]	[0.012]	[0.012]	[0.012]	[0.012]
<i>GII[0-1]</i>	-0.334***	-0.332***	-0.332***	-0.337***	-0.332***	-0.336***	-0.337***	-0.337***
	[0.086]	[0.087]	[0.088]	[0.086]	[0.087]	[0.086]	[0.087]	[0.086]
<i>Techn</i>	-0.43	0.423	0.134	0.228	0.031	-0.023	0.316**	0.000
	[1.339]	[0.798]	[0.344]	[0.515]	[0.090]	[0.072]	[0.143]	[0.143]
R ²	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72
N	1073018	1073018	1073018	1073018	1073018	1073018	1073018	1073018
Under	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Weak	634.48	635.25	630.32	624.78	640.5	633.91	631.83	637.43

Notes: as under Table 7. Country, industry and time dummies included. Data on *Techn* from EUKLEMS expenditure on technology. *Techn/VA*: I_IT: Computing equipment, gross fixed capital formation; I_CT: Communications equip., gross fixed capital formation; I_RD: R&D, gross fixed capital formation; K_IT: Computing equipment, nominal capital stock; K_CT: Communications equip., nominal capital stock; K_RD: R&D, nominal capital stock; Kq_IT: Computing equipment, real fixed capital stock; Kq_CT: Communications equipment, real fixed capital stock; Kq_RD: R&D, real fixed capital stock.

Table 9A. Estimation results – GII as wage determinant in Europe, robustness: elimination industry by industry

Dep.var: log hourly wage (gross)	Elimination industry by industry		
	Mean coefficient (1)	Min coefficient (2)	Max coefficient (3)
<i>RTI</i>	-0.388*** [0.011]	-0.395*** [0.013]	-0.376*** [0.010]
<i>GII[0-1]</i>	-0.252*** [0.084]	-0.320*** [0.098]	-0.198*** [0.067]
R ²	0.76	0.75	0.77
N	1112762	921692	1183087
Under-identification	0.00	0.00	0.00
Weak identification	737.8317	481.86	2207.11

Notes: as under Table 7. Mean/Min/Max coefficients – average/min/max values of coefficients of specifications in which one by one industry are excluded. R², N, Under-identification, Weak identification also reported as mean/min and maximum value of the statistics.

Source: own elaboration based on data from EU-SILC and WIOD

Table 10A. Estimation results – GII as wage determinant in Europe, robustness: elimination country by country

Dep.var: log hourly wage (gross)	Elimination country by country		
	Mean coefficient (1)	Min coefficient (2)	Max coefficient (3)
<i>RTI</i>	-0.248*** [0.081]	-0.289*** [0.080]	-0.156* [0.086]
<i>GII[0-1]</i>	-0.388*** [0.011]	-0.396*** [0.011]	-0.376*** [0.009]
R ²	0.76	0.75	0.77
N	1170568	1122674	1193676
Under-identification	0.00	0.00	0.00
Weak identification	643.7139	435.45	1016.68

Notes: as under Table 7. Mean/Min/Max coefficients – average/min/max values of coefficients of specifications in which one by one industry are excluded. R², N, Under-identification, Weak identification also reported as mean/min and maximum value of the statistics.

Source: own elaboration based on data from EU-SILC and WIOD

Table 11A Estimation results – different time periods of the analysis

Dep.var: log hourly wage (gross)	Different periods of the analysis	
	2004 - 2008 (1)	2009 -2014 (2)
<i>RTI</i>	-0.388*** [0.012]	-0.389*** [0.011]
<i>GII[0-1]</i>	-0.321*** [0.094]	-0.169** [0.079]
R ²	0.78	0.76
N	439970	773952
Under-identification	0.00	0.00
Weak identification	694.88	598.78

Notes: as under Table 7. Source: own elaboration based on data from EU-SILC and WIOD

Table 12A. Estimation results – GII as wage determinant in Europe, comparison with classic offshoring measure (GII_tier1)

Dep.var: log hourly wage (gross)	GII_tier1	GII_except_tier1
	(1)	(2)
<i>RTI</i>	-0.388*** [0.011]	-0.389*** [0.011]
<i>GII[0-1]</i>	-0.381*** [0.122]	-0.722*** [0.240]
R ²	0.77	0.76
N	1213922	1213922
Under-identification	0.00	0.00
Weak identification	219.91	181.92

Notes: as under Table 7

Source: own elaboration based on data from EU-SILC and WIOD

Table 13A. Wages by RTI quartile and by country, 2014

	quartile 1 (the least routine)	quartile 2	quartile 3	quartile 4 (the most routine)
AT	24.25	17.08	16.11	16.40
BE	25.63	22.96	19.21	17.02
BG	2.91	1.77	1.99	1.82
CH	43.79	36.25	27.00	24.11
CY	17.75	11.90	8.93	6.52
CZ	6.73	4.56	4.77	4.14
DE	23.68	19.41	14.62	13.71
DK	32.40	31.42	25.70	23.40
EE	7.96	5.11	5.59	4.35
EL	11.62	8.55	6.97	6.41
ES	16.74	11.81	10.43	8.81
FI	26.48	20.37	15.54	16.42
FR	20.28	15.72	12.53	13.58
HU	4.89	3.16	3.17	2.91
IE	31.30	24.75	17.64	18.19
IT	18.60	13.82	12.71	11.27
LT	5.12	3.75	2.99	2.96
LU	39.48	28.55	20.68	17.26
LV	5.98	4.39	3.25	3.47
MT	14.16	9.93	8.24	8.21
NL	32.01	27.30	22.73	21.25
NO	40.53	36.24	30.99	28.09
PL	6.19	3.58	3.63	3.64
PT	10.77	6.15	5.22	4.68
RO	2.70	1.76	1.72	1.63
SE	24.11	21.85	17.60	17.11
SI	7.57	7.66	7.64	6.27
SK	5.43	4.09	3.93	4.04
UK	25.33	19.36	14.44	12.74

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